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THE HARVESTING, GINNING AND CLEANING OF COTTON

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The Harvesting, Ginning and Cleaning of Cotton

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1. The most significant development in recent years in the harvesting of seed cotton i.e. the spinnable fibre (called lint) with the seeds still attached to it, has been the successful introduction in the United States of mechanical methods. Thus, in 1949 only 6% of the crop was mechanically harvested, with 9,500 machines in use, whereas in 1955 23% was harvested mechanically using 41,800 machines(1), while in 1961 this proportion had risen to 59%(2).

2. Harvesting machines fall into two classes: strippers and spindle pickers, the latter often being referred to merely as pickers. The first type of machine removes the bolls, as the seed-pods are called, by, in effect, combing them from the stems of the plant. The method does not discriminate between ripe, opened bolls and unripe ones and if any leaves are present on the plant at the time a large proportion of these will also be collected. Spindle pickers are more sophisticated machines and operate by bringing rotating spindles into contact with the lint itself which becomes exposed when the bolls ripen and open. The spindles are grooved, knurled or moistened so that the lint adheres to and becomes wrapped round them. The spindles travel on an endless belt and when loaded move to another part of the machine for the lint to be removed and stored. Both types of machine have been fully described by Smith(3).

(1) Brown, H.B. and Ware, J.O., Cotton, McGraw-Hill Book Company, Inc., 343,New York (1958).

(2) United States Department of Agriculture; Charges for Ginning Cotton etc., Season 1961-62 (May 1962).

(3) Smith, H.P., Farm Machinery and Equipment, McGraw-Hill Book Company, Inc., New York (1955).

3. The difference between the two types of machine in their ability to discriminate between seed cotton and foreign matter (called trash) is clearly shown in Table 1, where a comparison can also be made with the two methods of hand-harvesting employed - picking, where the aim is to select only ripe seed cotton, and snapping where the whole boll is removed by breaking it off at the stem. It will be seen that machine and hand picking produce substantially the same results but that machine stripping is distinctly less discriminating than snapping, both of the last two methods being much worse than the first two.

4. The proportion of cotton harvested by the various methods varies widely from region to region in the United States, being influenced by the particular system of land tenure, the nature of the farmland, the climate, the supply of seasonal labour, the level of wages, the price of cotton and other factors. Thus, in the 1957-58 season all the cotton was hand-picked in Virginia compared with only 1% in Oklahoma, where 50% was hand-snapped and 49% was machine-stripped, while in California 70% was machine-picked compared with virtually none in Alabama, Georgia, North and South Carolina, Tennessee and Texas(4).

5. In favourable conditions a mechanical picker, which may cost from 4,000 U.S. dollars for the simplest type without a tractor, up to 19,000 dollars for a two-row self-propelled one, will harvest the equivalent of a 500-lb. bale of cotton in about an hour; a mechanical stripper, which costs less, will gather a bale in half that time; the average hand-picker will take nearly 100 hours. These facts provide, however, only part of the information necessary to decide whether the use of mechanical harvesting will prove economic. If no change is made in the procedure at the next process, where the spinnable cotton fibre is removed from the seed, a process known as ginning, then, compared with hand-picked cotton, the machine-harvested cotton will contain more trash after ginning, be graded lower, and will command a lower price. Furthermore, an allowance must be made for the cotton that the machines fail to pick, which may be in the region of 10%.

6. Studies of this kind have been made by Crowe(5), by Butler and Streetman(6) and by Hedges and Bailey(7). They show how the break-even point depends

(4) United States Department of Agriculture; Charges for Ginning Cotton etc., Season 1957-58 (May 1958).

(5) Crowe, G.B., Mechanical Cotton Picker Operation in Yazoo-Mississippi Delta, Miss. Agr. Expt. Sta. Bul. 465 (1949).

(6) Butler, C.P. and Streetman, H.L., Economics of Mechanical Cotton Picking in South Carolina, S.C. Agr. Expt. Sta. Bul. 399 (1952).

(7) Hedges, T.R. and Bailey, W. R. Economics of Mechanical Cotton Harvesting, Calif. Agr. Expt. Sta. Bul. 743 (1954).

on the wage level for hand-picking, the intensity of use of the machine, and the yield per acre of the crop. Since these studies have been made the issue has been further complicated by the installation of lint-cleaning equipment at the ginneries, the number of such installations in the United States having increased from under 30 in 1948 to over 5,000 by 1961. According to Nickerson(8) the ginneries are much more efficient in removing leaf today than they were before the days of mechanical harvesting.

7. The defoliation of the cotton plant by chemical means before mechanical harvesting takes place is virtually essential, except where the onset of frost has already caused the leaves to fall, and it is also of assistance when hand-picking in making the bolls more accessible and in preventing their rotting. Successful defoliation is not easy to achieve since an insufficient quantity of defoliant will not cause the leaves to fall while an excess will kill the leaves prematurely before the natural processes causing them to fall have had time to be effective and the dead leaves will remain firmly attached to the plant. Moreover, the desirable quantity of defoliant to apply varies with the climate, the soil and the condition of the plant. A further aim is to prevent the subsequent growth of new foliage.

8. The research in this field has been described by Eaton(9). Among the most useful chemicals are calcium and monosodium cyanamides, which may be applied as dusts, and a wider range which may be used in the form of sprays - endothal, monosodium cyanamide, pentachlorophenol, potassium cyanate, magnesium chlorate hexahydrate, sodium chlorate, sodium chlorate-pentaborate, sodium monochloro-acetate. The addition of amino triazole to some of these has helped to prevent the re-growth of foliage.

9. Mechanical harvesting has not so far made any headway outside the United States, though a few machines have been exported to Russia, because, on the whole, a good supply of seasonal labour has been available for hand-harvesting in the other cotton-growing countries. The opportunity that hand-picking offers of producing cotton relatively free from foreign matter is not, however, always seized. As regards avoiding the obvious contaminants such as leaf, stalk and sand, the correct procedure is largely a matter of good organisation, but an additional requirement is the appreciation of how

(8) Nickerson, Dorothy. Recent Trends in Trash Content of Raw Cotton Create a Problem in Grade Standards. Cotton Research Clinic, National Cotton Council of America, 8, (1962).

(9) Eaton, F. M., Physiology of the Cotton Plant, Ann. Rev. Plant. Physiol., 6, pp.299-328 (1955).

much harm can be done in processing and in the final product (cloth or garment) by the presence of minute amounts of any foreign fibres such as jute, which may originate from the sacks in which the seed cotton is placed, or specks of tar which may arise from the use of bituminised paper sacks for the same purpose.

Ginning

10. The machines employed for the separation of the lint from the seed are called gins and are of two kinds: saw-gins and roller-gins. In the first the lint is torn from the seed by the teeth of rapidly revolving circular saws; in the second the lint makes frictional contact with a rotating roller, covered with leather or similar material, and is pulled from the seed while the latter is held back by a knife-edge. The saw-gin is much more productive than the roller-gin but may damage finer and longer lint and it is for such cottons that the McCarthy type of roller-gin is mainly used. Roller-gins can also be employed for shorter lint attached to smooth seeds and are widely used in India for this purpose, but as many are of a relatively primitive type and liable to crush the seed, producing stained cotton, their use is undesirable.

11. The advent of mechanical harvesting in the United States has greatly stimulated the elaboration of the saw-gin, to such an extent that the actual removal of the lint from the seed is only one of six operations that take place when the seed cotton is processed in the most modern machines(10). The need for improvement arose from two features of mechanical harvesting: the application of moisture to facilitate spindle-picking and the presence with both types of mechanical harvesting of abnormal amounts of trash. If the seed cotton is too damp, ginning will be unsatisfactory because of clogging of the saws, cutting of the lint or its compacting into small lumps. The modern gin is therefore equipped with arrangements both for drying and cleaning. These facilities are also obviously of value for hand-picked cotton that is damp or contains excessive trash, but arrangements can be made to by-pass them when ginning clean, dry hand-picked cotton so as to avoid unnecessary processing.

12. The full sequence of operations is as follows. The seed cotton to supply a battery of 4 gins is sucked pneumatically from the delivery or storage containers and fed at a controlled rate to the first hot-air dryer. The partial drying at this stage facilitates the cleaning that takes place before lint separation. Larger pieces of foreign matter are removed by revolving toothed cylinders and smaller pieces by threshing over screens. After further drying the cleaning is repeated before the material is distributed to the individual gins where further drying and cleaning take place before the lint is separated from the seed. Finally, the lint itself is cleaned after separation from the seed and the cleaned lint is conveyed pneumatically to the presser and baler.

(10) Brown, H.B. and Ware, J. O., Cotton, McGraw-Hill Book Company, Inc., 374, New York (1958).

13. The whole process is highly automatic; the covering, tying and removal of the bales are almost the only operations to be performed by hand. Large quantities of air are used for conveying, about 60% of the total power for ginning being taken by the fans.

14. The foregoing account provides a strong contrast with the description given by Tippett(11) of the ginneries of the Sudan Gezira Board where all the cotton is processed on roller-gins and the feeding of seed cotton to the gins, the collection of lint, its feeding to the bale press and its trampling, are all done by hand or foot. In the report cited Tippett makes ten recommendations(12) concerning the initiation of research into ginning in the three countries concerned. He places particular emphasis on the need for a systematic study of the effects of different gin settings and conditions, with particular reference to roller-gins.

15. Much research on saw-gins has already been done at the U.S. Department of Agriculture Cotton Ginning Laboratory at Stoneville, Miss., and more recently at additional laboratories at Mesilla Park, N. Mex., Chickasha, Okla., and Clemson, S.C. Among the questions investigated has been the influence of seed-roll density and saw speed on the quality of the lint and on the ginning capacity and power requirements. The problem of handling trashier cotton is becoming more acute and continuing research is necessary into how to improve the cleaning of cotton during ginning without impairing its value for later processing.

Cleaning

16. Most of the cleaning of the lint - in the absence of lint-cleaners at ginneries, all the cleaning - is performed at the spinning mill in the course of the opening process, a necessary preliminary to yarn manufacture, in which the compressed cotton from the bale is loosened, opened up, blended and made into a relatively uniform fleece or lap. Even where lint-cleaners are now widely used at ginneries, as in the United States, an appreciable amount of trash remains to be removed by the spinner. Nickerson(13) estimates that the average non-lint content of the U.S. 1961 cotton crop lies between 1½% and 10%, depending on the grade.

17. Considerable progress has been made in recent years and there are now on the market several makes of opener with greatly improved cleaning powers. It is claimed for one that it is equivalent to four beaters of the traditional type. Another important factor is that the amount of good lint rejected with the trash should be kept to a minimum. In this respect, too, these modern

(11) Tippett, L.H.C., Report on a Tour of Cotton Ginning Industries in the Sudan, Uganda and Tanganyika. Empire Cotton Growing Review, 197,(1960).

(12) Tippett, L.H.C., ibid, 206.

(13) Nickerson, Dorothy. Recent Trends in Trash Content of Raw Cotton Create a Problem in Grade Standards. Cotton Res. Clinic, National Cotton Council of America, 8, (1962).

machines show to advantage. Tests on another make of machine showed that there was only 17% and 13% of lint in the waste rejected at the two cleaning points compared with 33% in the waste from a conventional opener.

18. These improvements have come about as the result of researches, carried out at the Shirley Institute(14),(15) and elsewhere(16), into the effectiveness of conventional opening machines and into the differences in aerodynamic properties between tufts of cotton of various sizes and the various types of trash. It was shown that the common practice of the spinner who cleaned his cotton more thoroughly by merely passing it through an additional machine of the same general type was very inefficient. Instead, the cotton should be opened up progressively into smaller and smaller tufts if any marked improvement were to be made. When this was done it was possible to make use of the differences in aerodynamic properties to cause, with the aid of carefully controlled air currents, the lint and trash to take divergent paths through the opening machine, so achieving the desired separation.

19. One danger with these newer opening machines is that in opening up the cotton to the extent required damage may be done to the fibres, particularly those of long staple, and any potential user should check that they are suitable in this respect for the cottons he wishes to process.

20. Further cleaning takes place in carding, a process in which the lap produced by the last opening machine is teased out, almost fibre by fibre, into a thin film, or web, before being condensed into a soft continuous rope called card sliver. During carding, many small particles of trash are eliminated which have been embedded in tufts of cotton and have hitherto failed to be removed. Nevertheless, sufficient of the lighter particles, consisting of fragments of leaf, stalk or seed-coat, may still be present to cause difficulty or extra expense in later processes.

21. This residual waste is now being dealt with effectively by fitting carding machines with web purifiers(17). Each unit consists of a pair of precision-ground hardened cylindrical pressure rollers between which the card web passes before being condensed into a sliver. The pressure between the rollers is such as to crush the trash particles without damaging the cotton fibres. Much of the pulverised trash falls out before the cotton is spun into yarn and any remaining is completely eliminated in finishing.

(14) Peirce, F.T., Kelly, J.F., and Coleman, Mary H., A Survey of Blowroom Practice, Journ.Text.Inst., 46, T 78 (1955).

(15) Bostock, W., Freeman, S.M., Shorter, S.A., and Williams, T.C., An Aerodynamical Study of the Opening and Cleaning of Cotton by Existing Machinery, Journ.Text.Inst., 46, T 171 (1955).

(16) Higuchi, K., An Experimental Study of Blowroom Machinery, Journ.Soc. Text. and Cell. Ind. Japan, 13, 783, 877, (1957); 14 26, 30, 467, 551, 627, 693(1958); An Aerodynamic Study of Cotton Tufts in Blowroom Machinery, J.Text.Mach.Soc.Japan, 11, No.7,9; No.8,14,No.11,11.(1958).

(17) Clinch, H.H. The Crosrol Cotton Web Purifier, Cotton Research Clinic, National Cotton Council of America, 61, (1962).

22. The rollers are arranged so that a uniform pressure is achieved across the whole width and knife-edged scraper blades keep them clean. Their surface speed is the same as that at which the web leaves the card but it is less than that of the rollers which draw away the condensed web. In this way the fibres are disturbed and the impurities loosened.

Conclusion

23. The implications of the foregoing for any particular country will depend upon its general state of development, whether it is a cotton-growing or a cotton-using country or both, its supply of capital and labour and their relative costs, and the state of development of its light engineering industry. For this reason local studies will be necessary to determine how far the developments outlined above are appropriate to the particular circumstances prevailing at the time, and as these may change rapidly continuing assessment will be necessary.

24. The experience of the United States should be freely made use of and it should be possible to draw valuable conclusions, concerning harvesting in particular, from the diversity of practice between the different regions noted in para. 4, applicable to countries covering a wide range of stages of development.

25. Where shortage of capital or foreign currency prevents the purchase of machinery from abroad local manufacture may be possible in certain instances. All capital expenditure should be carefully examined from the standpoint of avoiding the purchase of obsolescent machinery.

26. The responsibility for producing clean yarn is shared between the grower, the ginner and spinner. The most economical way of apportioning that responsibility among them is an important but complex problem the solution to which will vary from country to country.

27. Since cotton is the most widely used of industrial fibres there will be few countries to whom the developments outlined in this paper are of no concern. Appreciable research effort in each country would appear to be justified and a sharing of experience desirable.

ANNEX

Table 1.

Average weight of harvested material (seed cotton plus trash) necessary to produce a 500-pound bale of cotton as supplied to the spinner; United States, season 1957-8[a].

Harvesting method	Weight of seed cotton plus trash (lb)
Hand-picked	1,430
Hand-snapped	1,989
Machine-picked	1,492
Machine-stripped	2,261

(a) United States Department of Agriculture; Charges for Ginning Cotton etc., Season 1957-58 (May 1958)

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